Out of Control: Barriers to Smart Power Strip Implementation

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ABSTRACT

The Consumer Electronics product category has been identified as one of the largest potential resources available to Demand Side Management (DSM) programs. The long list of existing devices and rapid pace of technological change make this resource particularly hard for implementers to quantify. Studies cataloguing duty cycles, power mode functionality, and specialized characteristics of peripheral devices must be updated frequently to adequately reflect the evolving consumer market. Adding further uncertainly to this effort is the highly unpredictable nature of human interaction with these devices. These issues raise a number of concerns for programs seeking to incorporate the consumer electronics resource into their savings portfolios.

Recently, the Smart Power Strip (SPS) has been perceived as a useful tool for reaching a significant portion of these savings by targeting several consumer electronics devices at once, rather than focusing on each individual device. Using homeowner surveys and established duty cycles of consumer electronics, Energy Trust of Oregon (Energy Trust) estimated the savings potential from implementing direct installs of the SPS. But how do the savings estimates track with actual realized savings once human behavior is taken into account? And would variable consumer acceptance of the SPS be something that efficiency programs could design around? This paper seeks to clarify some of these questions encountered with implementation in both market based and direct install based approaches to DSM, and offers suggestions to programs looking at utilizing these devices to capture part of the available electronics resource.

Introduction

The recently adopted 6th power plan from the Northwest Power and Conservation Council (NWPCC) identified consumer electronics as one of the largest and most promising new areas of energy efficiency resource potential. About 15% of the savings in the residential sector could be achieved by reducing the overall energy consumption of TV's and Set Top Boxes alone. Furthermore, a recent study out of the Energy Center of Wisconsin found that roughly 20% of the total electricity use in a home comes from consumer electronics devices. Energy efficiency programs across the country are scrambling to find cost-effective methods to get at this source of savings. However the role that traditional resource acquisition programs play in this market is undefined. The broad range of consumer electronic devices, their differing modes of operation, and the behavior surrounding their use represent significant barriers to the development of effective programs aimed at capturing this resource on a larger scale.

To develop consumer electronics savings potential estimates, NWPCC contracted with Ecos in early 2009 to gain a better understanding of the trends and consumption rates for a suite of four key consumer electronics products currently in the marketplace. Applying duty cycle data gleaned from the 2006 Ecos/LBNL field research study in California, adjusting for regional sales data and current market practices, and approximating trends for consumer electronics in the future, NWPCC estimated Pacific Northwest loads and resource potential over the next 20 years for televisions, set-top boxes (STB), and residential and commercial computers & monitors.

The 6th power plan data suggests that reducing television consumption levels could provide some of the largest savings available to the Pacific Northwest. In an effort to expand consumer electronics resource acquisition beyond established commercial computer and monitor programs, a collaborative effort between the Northwest Energy Efficiency Alliance (NEEA) and several other regional alliances was formed to deliver a midstream incentive program to raise the efficiency levels of consumer electronics sold through retail. The program has initially focused on televisions and will likely add other entertainment devices in the near future.

With the success of these regional programs in the new products markets, traditional resource acquisition programs like Energy Trust are looking to the devices already in the home for savings opportunities. In order to investigate this source of potential savings, Energy Trust teamed up with Ecos to embark on several small and inexpensive studies to assess the savings potential for a few program initiatives designed to target devices that use the most energy. This paper describes how the development of a low-cost savings estimation strategy was used to evaluate the potential for consumer electronics savings in homes and how this effort coupled with two pilot studies are being used to inform Energy Trust program managers of the potential barriers of incorporating these devices into their DSM portfolios.

Getting to Know your Smart Strip

In an attempt to capture savings from a suite of consumer electronics devices commonly found in homes, Energy Trust first decided to investigate the use of Smart Power Strips (SPS). These products were market ready and had produced a lot of interest both from program managers and consumers asking about available incentives, as well as misleading claims about energy savings in some cases. The SPS was attractive because it was a potential low-cost solution for reducing the standby losses in multiple devices all at once. At the time, two predominant types of models were available in retail outlets focusing on the residential market: the load sensing model and the timer based model.

Load sensing power strips use a single control outlet that is always supplied power. The other 5 outlets on the power strip receive power only when the control outlet is energized thereby eliminating standby losses on the remaining “slave” outlets. The device which ends up occupying the control outlet varies somewhat depending on the use, but in general it is the single device that all other devices in the power strip need in order to function, or the device that is used most often. In the case of an entertainment center, this is commonly the TV. For a home office, the control outlet is typically the computer.

Timer based power strips operate in the same manner that a standard mechanical house timer or thermostat operates. A schedule is set to turn off all the devices in the power strip for a period of time, and then back on again at a later time. On some timers, this can be set to vary on a 7-day schedule, however most commonly a simple dial is used to set a daily on/off schedule.

The first step was to determine which type of SPS would be best to use in an efficiency program. Energy Trust contracted with Ecos to perform lab testing of all commercially available SPS devices and provide a comparison of base power consumption, ease of install, flexibility, and cost. At the culmination of this lab testing, both a load sensing model and a timer based model were selected and the suggestion of a 30 home metering study was recommended as a next step towards evaluating device power consumption levels compared to the previously established duty cycles. However, because Energy Trust was considering incorporating these devices into their DSM portfolio by way of installing them during their Home Energy Reviews (HER), the first logical step appeared to be a simple verification to test whether a market even existed.

Assessing the SPS Market Potential

Moving slowly and cautiously as energy efficiency programs often do, Energy Trust decided to first gather some additional information before the launching into a 30 home pilot. Since the larger pilot effort would have been somewhat costly and time consuming, and because stated claims of energy savings from the SPS were still in question, Energy Trust developed a low cost and easy to implement solution to gain a better estimate of savings potential per home in its service territory. Utilizing its free home audit program, Energy Trust was able to capture penetration levels of major electronics through in-home visual inspections. This data was then used to create a stock assessment of existing electronics devices, and by applying the LBNL duty cycle estimates to the device mix, would allow for the estimation of savings that could be expected from implementing an SPS in each home. By obtaining this data Energy Trust would not only gain insight into the savings potential, but also be informed about the need to continue with a 30 home metering study to further refine the duty cycle estimates for electronic devices.

For each house visited during the month long study, in addition to the energy review that the advisor would already be undertaking, a simple stock assessment of consumer electronic devices was taken for two main electronics nodes (home office and entertainment center) and entered into the checklist shown below in Table 1. The homeowner would not be directly involved with the stock assessment process, other than allowing the reviewer to survey what electronic devices were found. By keeping this assessment simple and free of homeowner engagement, the additional time imposed on the energy advisor would be kept to about 5 minutes. Additionally, because on average each advisor performs a review of roughly 5 homes a day, the month long study required training only 2 advisors. By covering roughly 10 homes a day, 5 days a week, this relatively short stock assessment effort was sufficient to produce a reasonably sized sample that accurately portrayed the existing stock of electronics devices found in each home.

In addition to the device mix, the advisor would also record the presence of an existing power strip and whether or not it was easily accessible. This additional information would help estimate how many homes might be eligible for a direct-install based program where a power strip may be easily replaced by an advisor while doing an energy walkthrough. If the power strip was not accessible, a SPS could not be installed by the advisor but could perhaps be installed by the customer if it were purchased in a store. Therefore, houses that did not have accessible power strips were still counted in a separate stock assessment matrix to evaluate the potential for a market based approach. The synthesis of this data along with the general stock assessment would help inform Energy Trust of the devices found on the two discrete nodes and would allow for the prediction of savings that could be expected from implementing an SPS given the mix of devices found in each home.

Table 1. Sample HER Stock Assessment Checklist

Electronics Node #1

Location? ☐ Home Office ☐ Family Room ☐ Living Area ☐ Bedroom ☐ *Other*_______________

Is there a power strip already present? ☐ Yes ☐ No
Is the Power Strip accessible? ☐ Yes ☐ No

Equipment associated with Electronics Node #1 (check all that apply):

Entertainment Center

Television (Size:)
☐ CRT
☐ LCD
☐ Plasma
☐ Rear Projection
☐ Don't Know
-Energy Star (☐Y or ☐N)
Cable Box
- Digital ☐ or Satellite☐
- DVR (☐Y or ☐N)
Peripheral equipment
☐ VCR - standalone
☐ DVD - standalone
☐ DVD/VCR combo
☐ Receiver
☐ Speakers (powered)
☐ Sub Woofer
☐ Game Console_______
☐ Audio Mini System
☐ Portable Stereo
☐ Chargers #______
☐Other______________

Home Office

Computer
☐ Desk Top
☐ Laptop
Monitor
☐ CRT
☐ LCD
Peripheral equipment
☐ Multi (Print/Copy/Scan)
☐ Photocopier
☐ Scanner
☐ Fax
☐ Printer
☐ Speakers
☐ Modem
☐ Wireless Router
☐ Phone/Answer Machine
☐ Chargers__#____
☐Other______________
☐Other______________

Survey Says?

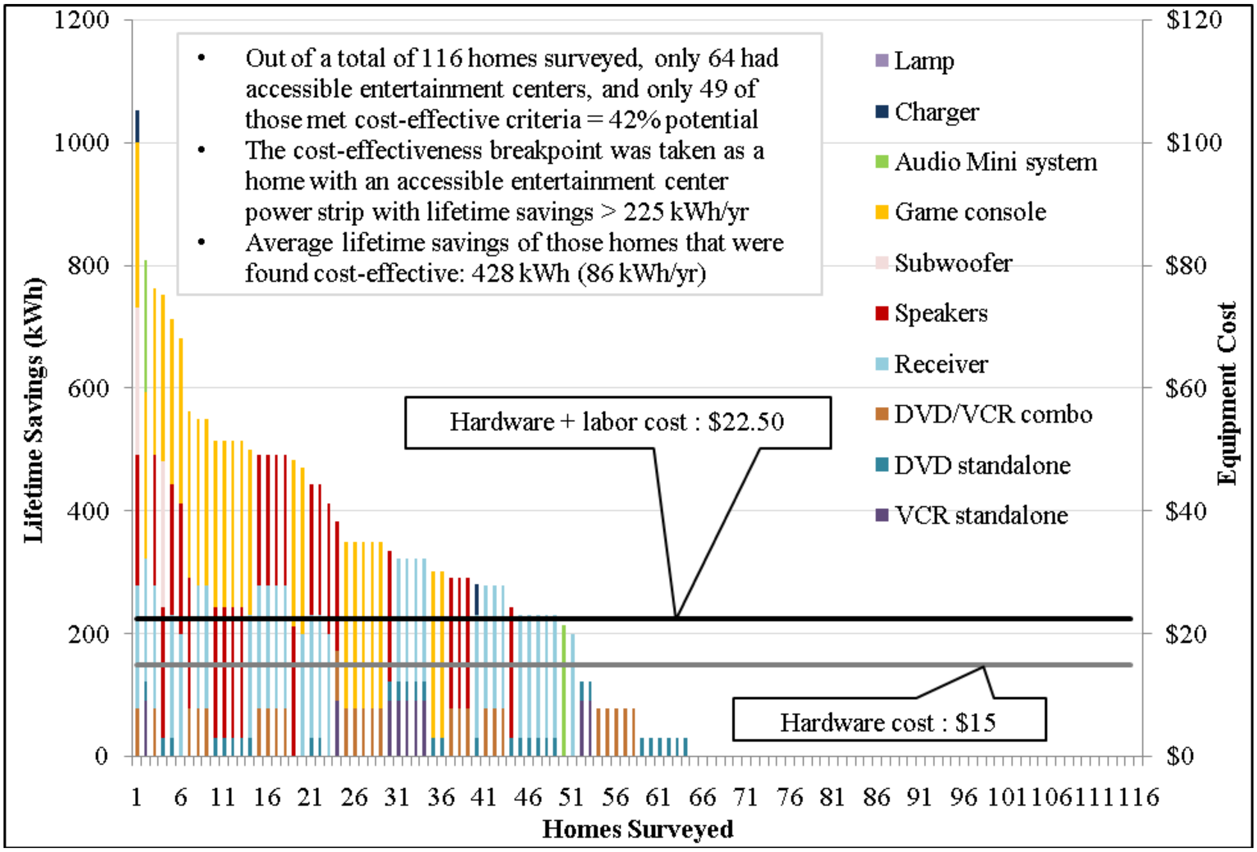
At the end of the stock assessment survey collection period, the persistence data was compiled by Ecos and previously established duty cycle rates were applied to the devices found in each home. From this, the program was able to view the makeup of electronic devices present in a typical home, and predict the SPS savings potential for each home given the combination of those devices. The results showed that out of a sample size of 116 homes surveyed during the month long study, roughly 55% had accessible entertainment centers that could benefit from a direct-install based program approach. (An additional 5% of homes had entertainment centers that were not accessible.) A summary of the device persistence found during the survey of those 116 homes is given below in Table 2 for both accessible homes and non-accessible homes to demonstrate the device penetration rates that were discovered.

Table 2. Entertainment Center Node Device Mix

	Device penetration % for 116 homes										
Accessible	CRT TV	LCD TV	Plasma TV	RP TV	VCR	DVD	DVD/ VCR combo	Receiver	Speakers	Game system	Audio Mini system
Y	7%	22%	5%	2%	5%	18%	13%	14%	11%	14%	2%
N	7%	10%	3%	3%	5%	12%	11%	14%	10%	8%	0%

Using this data Energy Trust and Ecos assumed that if a direct-install based program did exist, that the HER advisor could self-select homes that had the minimum product mix that met the cost-effective criteria, and therefore deliver reliable savings to the program. A cost threshold of $15 for the purchase of the SPS, plus the expected labor to install it using the HER advisor (valued at $7.50 for 15 minutes of work) was used to establish a cost-effectiveness threshold level for a direct-install based program. After the survey data was categorized, a device mix profile for each home was built with the results charted in order of most savings potential to least. It was found that out of the 64 homes that had accessible power strips, only 76% of those had enough devices to be cost-effective and warrant the installation of a SPS by an advisor. The savings used to evaluate the potential cost-effectiveness for the program was then taken as the average savings of homes that were seen above the cost breakpoint of $22.50, which was estimated at 86kWh/yr using LBNL duty cycle estimates. The graphical results from the direct-install based entertainment center load sensing power strip are shown in Figure 1 below.

Figure 1. Entertainment Center Stock Assessment Results – Direct Install

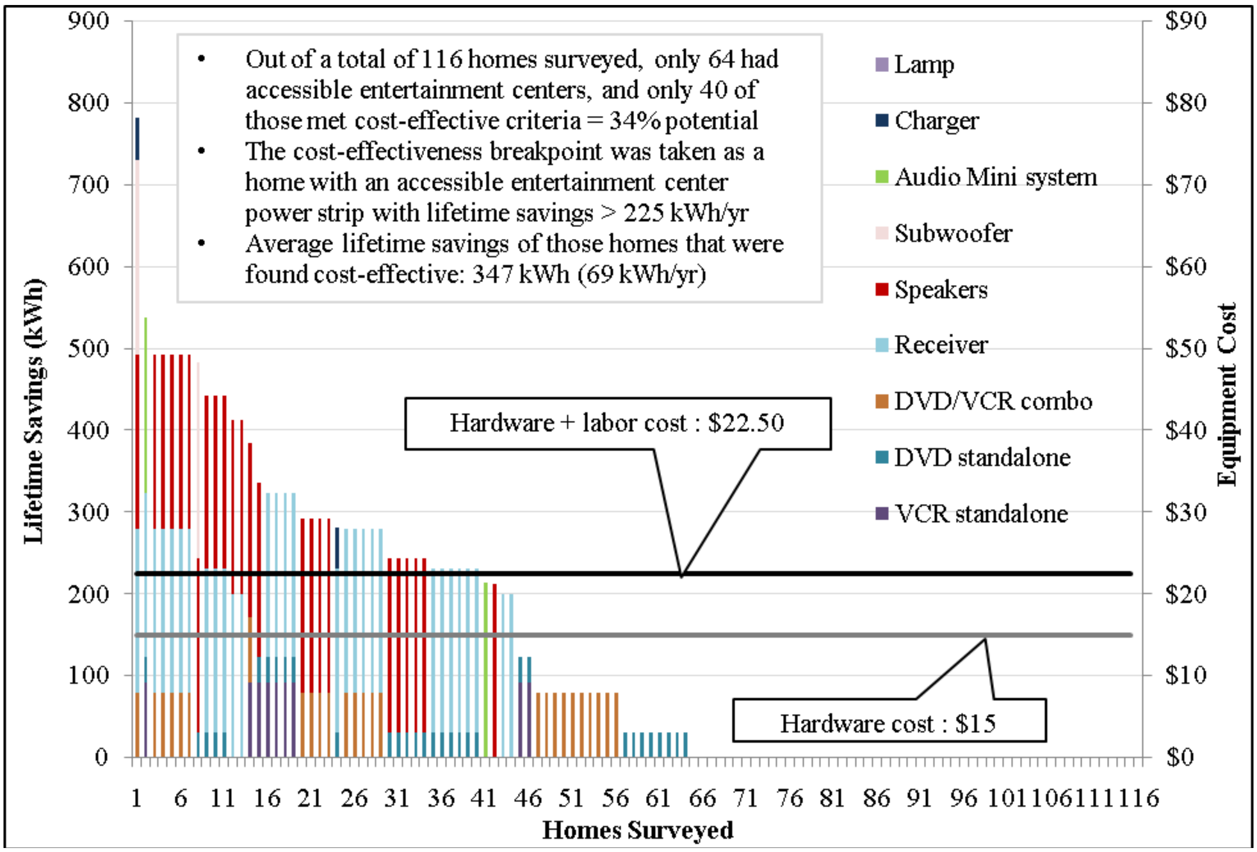


Source: Smart Plug Strip Final Presentation, July 2009

It is important to note that although the current generation the of load sensing SPS lacks labeling that instructs consumers about which devices should be plugged into which outlets, Ecos and Energy Trust felt that STB devices should intentionally be left off the load sensing SPS savings estimate shown above because of the way homeowners typically interact with these devices and the way in which they download content. Since STB's continue to download programming content even when the TV is off, they typically would not be plugged into a load sensing power strip controlled by a television. By removing the STB's, a estimate of potential savings from devices commonly plugged into load sensing power strips is shown. An alternate approach for capturing savings of STB's found in homes is explained further in this paper.

As initially assumed and further qualified by the above graph, a consumer with many devices on one "node" stood to save the most given average duty cycle assumptions. Furthermore, with a relatively small upfront cost for the SPS, and a minimal labor cost to have an HER advisor directly install one, the SPS at first appeared cost-effective for many of the homes in the sample study. But by looking closer at the survey data it became clear that cost-effectiveness was highly dependent on only a few select devices, (most notably game consoles) and the assumed variability surrounding the operation of these devices raised concerns about implementing an SPS program on a larger scale. Evidence of game consoles losing saved information when plugged into a SPS controlled by the TV led Energy Trust to believe that these devices may not remain connected to a SPS, and therefore not realize savings. Looking at the same stock assessment information given in the above graph with Game Consoles removed, the market potential is shown to be even lower, as indicated in Figure 2.

Figure 2. Entertainment Center Stock Assessment w/o Game Consoles – Direct Install



Source: Smart Plug Strip Final Presentation, July 2009

In theory, even with a controlled roll-out using a direct-install program where homes would be selectively chosen to receive an SPS device depending on the right electronics mix that resulted in cost-effective savings, considering that the savings estimates above represent an upper bound (if you accept the LBNL duty cycles) variability would most likely lead to less savings. Additionally, the 34% market potential seen in Figure 2 above is assuming that 100% of the homeowners that did receive an SPS not only installed the devices in the correct outlets to realize those savings, but that they kept them there for the 5 years used in the cost-effective screening. Since many questions still remained over how effective a SPS direct-install approach would be through the HER program even if it was cost-effective, a small field test was suggested to gain more knowledge in lieu of launching a larger program pilot effort or a 30-home metering study.

On to the Field Tests

In order to test the installation of an SPS in a controlled environment before installing them in the field during home energy audits, field tests were run on two homes in the Durango, CO area. These additional tests allowed staff the opportunity to evaluate/refine site visit protocols, estimate the amount of time that would be required on site to install the SPS, work out the difficulties of metering, and receive some customer feedback on satisfaction with the product. Furthermore, by metering the device energy consumption in these two installations, staff were able to examine if savings estimated using the stock assessment survey and LBNL Duty cycle data tracked well with actual installations.

Even though the field test sample size was small, this was viewed as a simple and low cost method to test the feasibility of incorporating SPS measures into a DSM portfolio. The information gathered would not only help validate duty cycle estimates, but it would also begin to identify customer acceptance barriers to smart strips in general. After all, if you can't find enough savings to warrant a direct install program where installations variables are more tightly controlled, you would not expect a retail program to perform any better. It was also hoped that this work might pave the way for additional research, perhaps at a regional level, to update duty cycle estimates of common electronic devices in the Northwest.

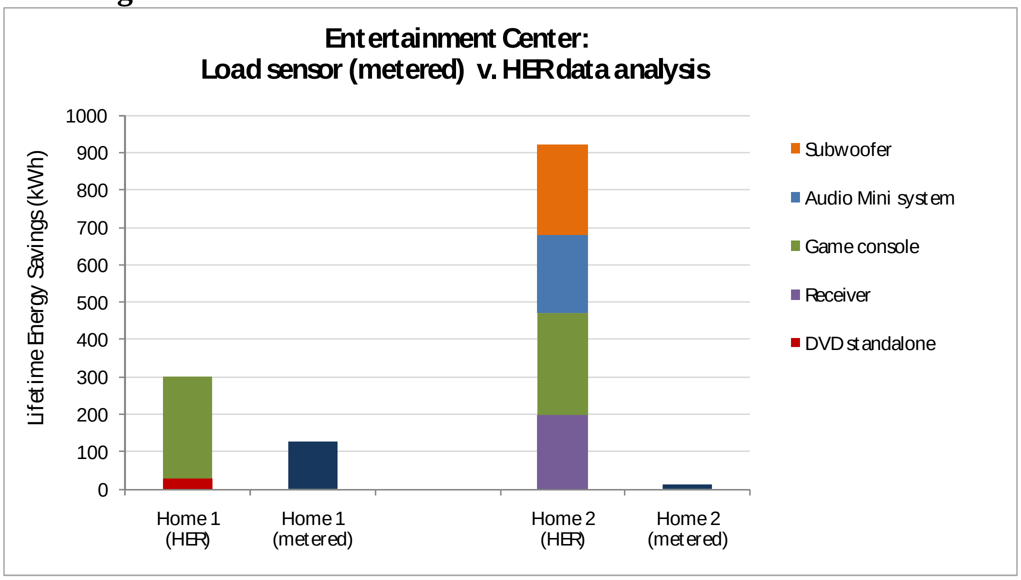
During the first site visit to each home in the study, the reviewer completed a device inventory similar to the 116 home stock assessment already done. A data logging meter was installed on each node using the current power strip. Standby/low power values for each device were recorded, system configurations with notes and photographs were documented, and the total time spent on the site was logged. With this device inventory completed and standby/low power values recorded, the analysis of predicted savings could begin. Using these values, instead of the previously established average device consumption values, would help estimate the potential standby power savings available.

On the second site visit, the reviewer removed the meters from each node and asked the homeowner to examine the SPS instructions and install the SPS themselves. Installation was documented and adjustments were made by the reviewer if needed. The reviewer then connected the SPS to single data logging meter on each node which was left in the home for a week. Participants were told to use their devices as they normally do, and a technical support line was provided to help with any questions or concerns participants may have encountered during the data logging period. For the purposes of this study a short timeline of one week was proposed in order to capture variations in occupant behavior over the course of weekday versus weekend use.

For the third and final site visit, the SPS and metering equipment were removed, and both nodes were returned to their original configurations. The advisor interviewed the participant for feedback on SPS operation, performance of equipment, and overall satisfaction with the SPS.

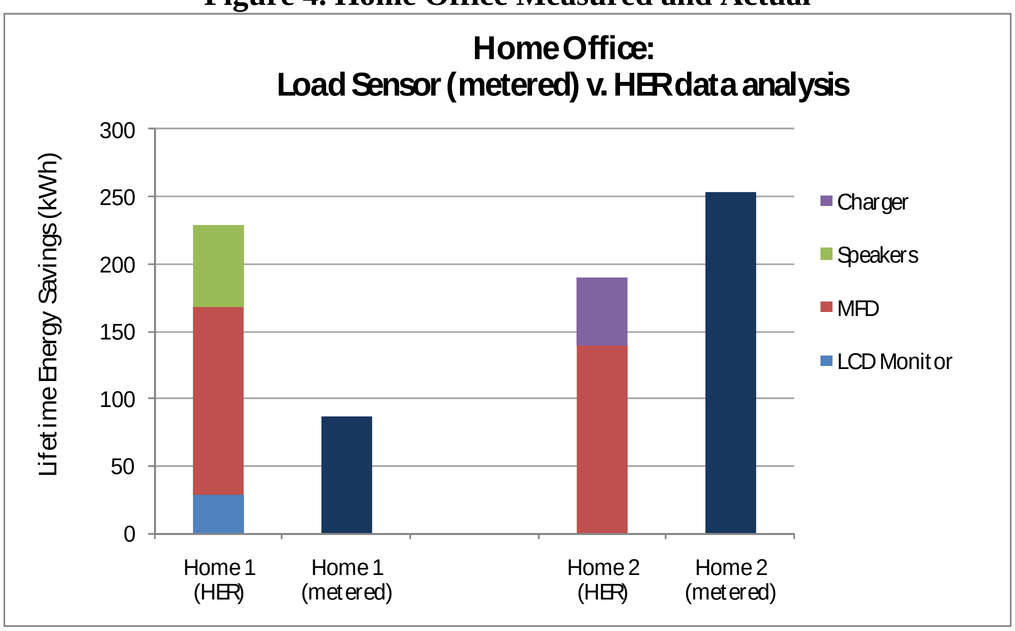
After all site visits were completed, Ecos used the information from the data loggers to compare the theoretical savings found during the first site visit to the actual savings found by metering for a week with data loggers. Similar to the Oregon stock assessment graph, a device mix for each node was developed and plotted against lifetime savings. Results for both nodes in each home are shown in Figures 3 and 4 below. The total savings potential found during the first site visit using the actual measured standby mode of operation is indicated under the HER columns. The actual duty cycle data collected over the 7 day period and the savings recorded by the logger are shown in the metered columns.

Figure 3. Entertainment Center Measured and Actual Results



Source: Smart Plug Strip Final Presentation, July 2009

Figure 4. Home Office Measured and Actual



Source: Smart Plug Strip Final Presentation, July 2009

It was surprising to see how widely the two homes differed, with one installation saving slightly more than was projected and the other saving significantly less. The primary explanation for this difference was discovered during the feedback session and was due to one homeowner's decision not to plug devices into the SPS that were intended to be used regardless of when the control device was on. In essence, plugging in a home theater system that was controlled by the TV could potentially yield over 180 kWh/yr in savings for a single home. In reality however, the homeowner wanted to listen to music regardless of TV operation, and therefore very few savings were actually realized through the use of an SPS.

When presented with these findings as well as the original stock assessment data which suggested that only a portion of the actual market potential existed that would fit a cost-effective criteria, program managers were very skeptical that either a direct-install approach, or a wider market based approach would produce enough reliable savings for their programs. Behavioral use stemming from the multiple device combinations possible on the SPS could not be easily controlled and therefore Energy Trust program managers were not eager to undergo a program roll-out with the possibility of highly variable savings being delivered. Additionally, a proposed regional study surrounding updated duty cycle estimates for various devices was also seen as unnecessary at this time since achieving reliable savings through the use of a SPS were viewed as being somewhat less dependent on the actual device energy consumption levels and more on how the occupant used them.

Targeting Savings for a Single Device – The STB Pilot Effort

With the SPS devices essentially off the DSM agenda for the near term, the set top box seemed like the next most likely opportunity for energy savings. This resource was identified as the second largest source of energy savings in the consumer electronics portion of the 6^{th} power plan. Focusing on a single device instead of a technology that tackles all devices seemed to be an approach that could deliver a consistent level of savings with less behavior variability. In addition, this was a device that was probably not going to work well with a power strip, but is probably the largest source of savings.

To assess the savings potential of using a timer turn to control the on/off times of a STB, Energy Trust again worked with Ecos to develop another audit delivered stock assessment and a 30-home pilot test. Similar to the prior consumer electronics stock assessment study, a simple checklist was developed with the addition of a few survey questions to gain insight into consumer STB use and general acceptance of the timer. The HER advisor again used this checklist during a walkthrough to take a stock assessment of STB's found in a home. Homeowners were then asked if they were interested in participating in the STB timer study.

For homeowners willing to participate in the study, digital timers are being installed along with Kill-a-Watt meters. This setup will be left in the home for a month to monitor the actual device duty cycle and effectiveness of the timer operation. At the end of a month, a call to the homeowner will occur and they will be asked to read the total kWh consumption on the meter to the Energy Trust representative over the phone, as well as answer a few questions related to their experience with the device. The Kill-a-Watt and STB timer will be left in the home for the participant to use at their discretion. Using the device on/off power mode data obtained during the HER walkthrough, the schedule set by the homeowner at the time of the timer install, and the kWh consumption over a month period, a clearer picture of device use and occupant behavior is hoped to be obtained.

This study is currently underway**.** Early results indicate that although the HER advisors were eager to engage in this pilot effort, homeowners seem reluctant. Advisors are having a hard time finding participants that were willing to engage in the month long metering study even though preliminary results show that almost 90% like the idea of a timer to turn off the STB. At the time of this paper however, only 57% of the homes included in the survey have been willing to undergo the month long survey. Although final results from the participants that did elect to undergo the survey were not able to be included in this paper due to timing overlap, one facet of the study that will be useful is the stock assessment portion that is cataloging device use, location, and type in each home. The data from this stock assessment study may prove useful if a better approach that resonates with homeowners for controlling STB off-hour use is found in the future.

Conclusions, Recommendations and Next Steps

The audit delivered stock assessment study proved to be a low cost way to gather information about the penetration of various electronics devices in the participant's homes. When combined with existing research, Energy Trust was able to estimate an upper bound for the energy savings potential for Smart Power Strips absent human error and acceptance issues. Considering that even under this best case scenario, only 1/3rd of homes were found to have cost effective installation opportunities, Energy Trust program staff were not very optimistic about a larger deployment of a direct install SPS, and even less optimistic about a retail based program.

The two home field tests suggested that behavior would play a large role in realized energy savings, further reducing the potential. Although the savings validation from these field tests could not predict the average device energy use or savings of a large scale rollout, they presented the case that behavior can be an uncontrollable variable in SPS use, and that consumer education on the use of the SPS and its benefits may be a better option for Energy Trust programs seeking to promote the device.

Energy Trust relies on these home audits as a significant source of savings and the more cost-effective direct-install measures that can be developed, the more viable these free audit programs will be when DSM programs have to stop screwing in light bulbs. Because Energy Trust's residential HER program requires predictable savings to remain cost-effective the promotion of these devices is unlikely to be widely accepted through a direct-install based approach. Unlike many widget based devices developed to manage homeowner behavior, it seems that the variability with the SPS is not only from the consumer behavior aspect, but also from the vast array of device configurations themselves. This introduces a second level of variability that is not commonly found acceptable to prescriptive DSM programs, which is why a specific device approach (i.e. STB timer) may work better at capturing consumer electronics savings rather than a collective approach. Also, by keeping the stock assessment study simple, the advisors time in the home was kept to minimum and audit staff expressed openness to future pilot projects because of this. Additionally, had Energy Trust gone forward with a direct install program through their home energy audits, the field tests would have provided valuable information related to troubleshooting potential installation issues, answering homeowner questions, and evaluating consumer feedback. Capturing this information prior to a rollout saves valuable program dollars and avoids complications for the advisors who are out in the field trying to implement energy audits as cost-effectively as possible.

It is recommended that efficiency programs seeking to evaluate the use of Smart Power Strips and timers in DSM programs look to emulate similar low-cost and easy to implement solutions to better understand market potential before engaging in any sort of larger rollout. By the end of the study period Energy Trust was able to decide that the energy savings potential did not outweigh the customer satisfaction and cost-effectiveness risks of any type of SPS rollout before spending large program dollars on an audit based program and expected follow-up evaluation. Preliminary results suggest that set top box timers may prove to be a more cost-effective approach to consumer electronics, but not by much. Additional information is still needed however to confirm that duty cycles in California are applicable to other regions like the Northwest. Had the resource potential been larger, or looked more promising, Energy Trust would have probably been more inclined to continue down this road to ensure savings tracked well with the actual device mix in the Northwest.

Finally, feedback from homeowners during all aspects of the study suggested that they were generally receptive to the concept of turning off electronic devices when they were not in use to save energy. Preliminary results from the STB timer study appear to reinforce this theme, and also tie in with SPS results from the field tests which suggest that participants are more resistant to saving energy when utilizing a device that limits their control. This feedback from homeowners during the field tests was extremely helpful in predicting potential program and savings barriers that could arise once the SPS was in place in the home. Table 3 below takes this feedback and links the implementation issues with the effect they had on the SPS savings and proposes a potential solution as a next step in advancing the SPS as a device.

Table 3. Feedback Solutions Matrix

Issue	Effect on savings	Potential Solution
Homeowner did not want to plug set-top box into a timer SPS. Reason was that the device was downloading during off hours, and so it needed to function even when the TV was off.	No savings were realized from off-hour STB operation.	Use a separate timer for the STB only or incorporate a timer into the load sensing device that would only be used for STB's.
Homeowner noted that the laptop could charge and avoid turning on the controlled outlets.	More savings were realized by keeping laptop on SPS control outlet.	None needed. This was an unforeseen benefit to the homeowner.
Outlets were too close together for devices with wide power adapters.	Limited the number of devices allowed per SPS. Savings diminished as fewer devices could be used per node.	Create wider spacing on SPS to accommodate larger transformer plugs.
Could not use the printer for other computers when the master computer is off.	Homeowner unplugged printer from SPS resulting in fewer savings.	Hard to incorporate an SPS when separate nodes share common devices. No solution.
SPS Timer outlets were harder to read than standard wall timers.	Incorrect time could be set for devices and reduce savings or increase homeowner dissatisfaction.	Use wall timers and locate next to STB for ease of adjustability.
Concern over game console systems not saving games if TV was turned off.	Game console was removed from SPS device after games were lost.	Consumer education or refinement of SPS to better accommodate game console use.

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